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**Status Update of Scallop Fishing Grounds
on the Scotian Shelf for 1993**

by

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ABSTRACT

Scallop beds on the western Scotian Shelf (NAFO SA 4X), Browns and German Banks, were managed under separate TAC's for the first time in 1993. The Browns Bank TAC was increased by 33 % to 600 t given the rise in catch-rates, the decrease in meat counts, and high abundance of size classes larger than 55 count. The 1993 catch-rates were the best encountered since the implementation of TAC in 1989. A seasonal profile of fishery performance was established after segregating data of 2 distinct scallop beds. A decline was observed in catch-rates during the course of the fishing season; they bounced back up with inclusion of new recruits in the catch near the end of the season. An arbitrary TAC of 200 t was set for German Bank. Additional removals far exceeded the TAC. Catch-rates of the deep-sea fleet were high with a count under 30 per 500 g.

Scallop beds on the eastern Scotian shelf (NAFO SA 4W), mainly Western Bank and Sable Island Bank, are exploited by comparison, on a competitive basis. The 1993 catches dropped 50 % from 1992, to 250 t with a small decrease in catch-rates. The most recent survey did not indicate an improvement in stock biomass.

RESUME

Les bancs de pétoncles de la partie ouest du plateau néo-écossais (OPANO SA 4X), les bancs Browns et German, ont été gérés par quota individuel pour la première fois en 1993. Le quota pour le banc Browns augmenta de 33 % soit 600 t étant donné la hausse des taux de capture, la diminution des comptes de chairs, et une abondance élevée des groupes de taille plus grande qu'un compte de 55. Les taux de capture observés en 1993 furent les meilleurs depuis l'implémentation de quotas en 1989. On a établi un profile saisonnier de performance de la pêche en séparant les données de 2 bancs de pétoncles distincts. Les taux de capture ont baissé au cours de la saison mais sont remontés avant la fin de la saison avec de nouvelles recrues dans les prises. Le banc German fut l'objet d'un quota arbitraire de 200 t. Des prises supplémentaires ont dépassé le quota de beaucoup. Les taux de capture de la flottille hauturière étaient élevés avec un compte de moins de 30 par 500 g.

Les bancs de pétoncles de la partie est du plateau néo-écossais (OPANO SA 4W), les bancs Western et de l'Île-de-Sable surtout, sont exploités en comparaison, sur une base compétitive. Les prises en 1993 ont subi une baisse de 50 % (250 t) avec une légère réduction des taux de capture. L'inventaire de stock le plus récent n'indique pas d'amélioration de la biomasse.

INTRODUCTION

Scallop beds on the Scotian Shelf offer alternatives to Georges Bank even though catch-rates have been lower on Western - Sable Island Banks but comparable on Browns Bank. Traditionally, the Scotian Shelf fishery has been pursued on a competitive basis. An enterprise allocation (E.A.) plan was implemented for the western Scotian Shelf (Browns Bank and German / Lurcher, Fig. 1) in 1989. Starting in 1993 Browns Bank and German Bank have separate management plans and individual TAC's; the allocation formula remains the same though. The fleet is still operating competitively on the eastern Shelf (Banquereau, Middle Grounds, and Western - Sable Island Banks).

The Browns Bank TAC was increased by 33 %, from 450 t in 1992 to 600 t in 1993; it was almost all caught (96 %). German Bank was reported to have exploitable stocks. An arbitrary TAC was set at 200 t to allow the allocation process. The TAC was caught; a fairly large amount of scallops were removed in addition to the TAC. Fishing activities on the eastern Scotian Shelf were spread out over a wide area due to the low catch-rates encountered.

METHODS

Fishery Information

There are two sources of information to estimate the respective fishery contributions of scallop fishing grounds on the Scotian Shelf. The Statistics Division, Department of Fisheries and Oceans, Halifax, compiles, on a yearly basis, landings by vessel size and by NAFO sub-subareas from sale slips issued by fish buyers. The other source of information about the origin of the catch is from logbooks. There are at times discrepancies between statistical and logged catches as NAFO sub-subareas are not tailored to the physical location of particular scallop beds and may cut a major scallop bed in two. This inadequacy of the statistics system was previously described in Robert *et al.* (MS 1984). As of November 1993, a dockside monitoring program was implemented to cover all landings from the deep-sea fleet. Quantity landed are monitored at dockside by an independent agency to enhance the quality of the catch information.

All vessels (over 25.5 G.T. or 14 m L.O.A.) fishing the Scotian Shelf are required to keep logbooks to record daily fishing activities. Daily log records supply information on the catch and its location and fishing effort such as hours spent fishing, width of gear, and number of crew. Catch-rate estimates may be computed when complete effort data (location, hours fished, gear, etc.) are provided with respect to the catch (Class 1 data). Total effort may be estimated according to the effort that generated the Class 1 catch. The productivity in terms of removals of a specific scallop bed may also be established assuming that the catch with known location is representative of the total catch from that bed.

Scallop Fleets

Two components of the Canadian offshore fleet may drag for scallops on the Scotian Shelf. The deep-sea fleet, L.O.A. over 19.8 m, is excluded from a 12 nautical miles zone near-shore, and waters in the Bay of Fundy and approaches north of latitude 43° 40' N following the Inshore / Offshore Agreement (fall 1986). The Bay of Fundy fleet, mostly L.O.A. between 14 and 19.8 m (Bay of Fundy licensed vessels), has to restrict its activities on the Scotian Shelf to the upper parts of the Lurcher Shoals above latitude 43° 40' N following the Agreement. The status of scallop beds above latitude 43° 40' N will not be addressed in this document.

The deep-sea fleet uses a New Bedford offshore scallop drag varying in width from 3.96 to 4.88 m. Two drags are fished simultaneously, one on each side of the vessel.

Catch Sampling

Sampling of the catch is sporadic and does not meet target levels to sample the catch adequately. Port coverage varies greatly, from none for southwest Nova Scotia ports like Yarmouth and Saulnierville to somewhat fair in the Lunenburg - Riverport area. Not all ports are necessarily involved in any particular Scotian Shelf fishery.

Survey Procedures on the Scotian Shelf

The catch distribution derived from log records for each particular fishing ground is used to stratify survey stations which are randomised within a low, medium, and high stratum. At times, an exploratory stratum may be added. Catches from the deep-sea fleet over the year prior to the survey are considered. Annual surveys are carried out during May on a Government research vessel. The 1993 eastern Shelf survey did not cover Middle Grounds. The Browns Bank annual survey covered the grounds as they have been exploited since 1991, an area of 500 km² approximately. The German Bank / Lurcher Shoals segment of the Scotian Shelf annual stock survey has not been carried out lately because of the low levels of fishing activity.

The survey gear was a 2.44 m wide New Bedford offshore dredge (75 mm ring size) lined with 38 mm stretch mesh polypropylene netting. Tows were of ten minutes duration; distance towed was determined from the continuous recording of Loran C bearings via a microcomputer or, exceptionally, from bearings taken at the start and the end of the tow. Catches were later standardised to a tow length of 800 m. For each tow, the following data were recorded: 1) shell heights in 5 mm intervals for all live scallops and cluckers (shells with both valves still attached at the hinge); 2) tow location (Loran C bearings); 3) depth (m); 4) compass bearing for direction of tow; 5) duration of tow (minutes); 6) substrate type; 7) fullness of the drag (count of the number of vertical rings covered by the catch); and 8) total scallop catch as a round weight (kg).

Standardized survey catch-rates were contoured to represent the spatial distribution of the scallop aggregations. Data points describe a three dimensional surface with latitude, longitude, and number of scallops per tow to be plotted. A surface is formed by defining Delaunay triangles from an algorithm found in Watson (1982); the data points become the vertices of triangles connecting nearest neighbour points. The surface between adjacent contour levels, in this case the relative abundance of scallops, is represented as darkening shades of grey. Contours may be smoothed by interpolating the surface by inverse weighting of gradients (slopes of triangles). The sides of the Delaunay triangles are divided into equal segments (chords) to establish the interpolation points. For example, dividing the sides into 4 segments gives 16 subtriangles. The interpolation points become new vertices. This method assumes that the data points near the point in question contribute more than distant points (see also Watson and Philip 1985). Each triangle is assumed to have a flat surface. The summation of the volumes of all triangles under the contoured surface is equal to the total volume, a potential abundance estimate for the survey area. The degree of interpolation will affect the volume estimates. Experimental work indicates that volume estimates stabilise with a minimum of variation (5 %) (Robert *et al.* MS 1989) after 16 or more subtriangles. A complete description of the procedure may be found in Black (MS 1988).

Fishery Performance on a Scallop Bed Basis

Catch data may be plotted from locations provided in logbooks to investigate the concentrations of fishing activity presumably related to abundance, hence location of scallop beds. Log returns for the Browns Bank fishery are excellent with over 90 % class 1 data. Isolines of catches may be drawn and surfaces contoured similar to the plotting of survey catch-rates, thus mapping the distribution of scallop beds. Browns Bank had 2 major scallop beds under exploitation in 1993. After segregating the fishery data according to which scallop bed they came from, a

seasonal profile of catches, catch-rates, and meat counts is drawn to examine the effects of the fishery.

Relevant Biological Information

Biological information dealing only with growth rate and allometry of meat weight on shell height are given here. Biological data has been gathered since 1982 as part of an on-going study of somatic and gonadal growth cycles.

Areas such as Sable Island / Western Bank have better sampling coverage from the commercial fleet than Browns Bank where fishing activity has only recently resumed.

Samples from 1982 to 1989 surveys and samples collected from the fleet up to 1989 were used in the analyses except for Browns Bank. Table 1 presents variables of von Bertalanffy growth curves and the number of scallop shells which rings have been read for each area. It also gives the regression parameters for estimating meat yield as a function of shell height and the number of animals examined. In an attempt to reduce seasonal effects in yield conditions, samples collected at all times of the year have been included in the analysis to approximate a 'year round' value. Some biological information was tentatively derived with a small sample from Banquereau Bank collected during earlier stock surveys until more material is assembled. The Sable Island area presents a wide range of depths (20 - over 100 m) where scallop concentrations occur, leading to a great deal of heterogeneity in growth patterns. However, all data were pooled together to generate one equation for the area. The growth curve parameters given for Browns Bank come from samples in the southern bank where about 500 shells were read; they might not apply reliably to the area fished now. Samples collected during 1989-92 from the grounds presently exploited were used for meat yield determination.

RESULTS

Scallop Fleets

Following the 1986 Inshore / Offshore Agreement, the Bay of Fundy fleet was restricted to a very small section of the Scotian Shelf, i.e. the northern Lurcher Shoals. The deep-sea fleet however, continued to exploit scallop grounds on the Scotian Shelf (Table 2). Good catches have sustained exploitation on the western Shelf, Browns Bank mainly; interest has increased slightly in 1993 with vessels fishing German Bank for the first time after a lapse of 7 years.

With a declining fishing performance on the eastern Shelf, fewer vessels used the area. However, the proportion of vessels fishing on the Scotian Shelf as a whole has steadily increased over the last 5 years.

To give methodical coverage to all fishing areas (Fig. 1) (from east to west), each area is looked at with respect to: a fishery profile, an estimate of its productivity in terms of distribution of scallop beds and abundance, catch sampling, and survey results. The Eastern Shelf includes Banquereau Bank, Middle Grounds, Western Bank, and the Sable Island area. The Western Shelf includes Browns Bank, the Tusket area, and German Bank / Lurcher Shoals.

Banquereau Bank

Historically speaking, Banquereau Bank (NAFO subarea 4V) has never been reported as a scallop-producing area. Catches average less than 10 t per year (Table 3). Highest landings (16 t) were reported in 1986. This trend could not be maintained as less than 1 t was landed annually for the next 5 years. Catches have originated from the westernmost section of Banquereau Bank, adjacent to Sable Island Bank. Around 3 t were caught in 1992 with slightly higher CPUE's. Catch

levels and the profile of catch-rates do not indicate the presence of an important stock biomass. Generally speaking, the fleet expands the area under exploitation in years of poor catch-rates on the eastern Shelf; catches are reported for Banquereau Bank under that scenario. 1993 is a case in point. Nearly 7 t (Table 3) were caught from the west tip of Banquereau; catch-rates were low.

The 1989 survey carried out six exploratory tows on Banquereau Bank. Abundance was extremely low based on only the oldest age class (Robert *et al.* MS 1990). The area has not been given survey coverage since.

Middle Grounds

Middle Grounds is a shallow bank of which 900 km² may carry commercial densities of scallops. Scallop production has been irregular over the last ten years (Table 4). From practically no landings reported in 1988, catches have been relatively low but rising gradually from 20 to 50 t. Catch-rates have varied little during that period and did not change from 1992 to 1993.

Sampling of the catch (Table 5) indicates that a wide range of meats are shucked with an average meat weight comparable to the ones obtained from Georges Bank. This profile varies little between years although only a small number of meats are weighed. Very low catches in 1988 prevented sampling of the catch. Since 1989 there has been an important weight drop (33 %) in the average meat, from 21.4 to 14.4 g which later stabilised around 15 g. Low catch volumes prevented sampling in 1991 and 1992. The average meat weight has dropped around 20 % in 1993 from when it was last sampled.

Stock surveys had shown low abundance of scallops except for the first survey in 1983. The prerecruit index rose significantly in 1988 but overall mean numbers at age are very low. Given the relatively low fishery performance no survey work was carried out between 1989-91. The 1992 Scotian Shelf survey had 8 tows on Middle Grounds (Table 6) to check the status of the stock. Tables 7 and 8 indicate a lower abundance than in the last survey (1988) especially prerecruits, although they are more numerous now than pre-1988.

Sable Island / Western Bank

The eastern Scotian Shelf has been exploited on a continuous basis for 14 years. On an annual basis landings have never exceeded 700 t. Western Bank and the Sable Island area have the main scallop beds exploited by that fishery. In years of poor performance, exploitation extends to the immediate vicinity of Sable Island, and Banquereau Bank and Middle Grounds (NAFO sub sub-areas 4Wf, g, h, j, l, and u designated here under the label of SA 4Wf-j). Prior to 1985 the fishery had low landings, usually under 100 t and low catch-rates (compared to Georges Bank) (Table 4). After this exploration period, landings increased substantially but CPUE's remained in the low range. The recent expansion of fishing activities around Sable Island and to the western part of Banquereau Bank continued in 1993 but with a considerable drop in catches, under 200 t. CPUE's concurrently declined by 15 % from already low rates in 1992. A map of catch-rate isopleths (Fig. 2) shows considerably more fragmented patterns on Western Bank compared to last year (Robert and Butler MS 1993); a small scallop bed to the northeast of Sable Island produced the best catch-rates. Since the beginning, this fishery has had a strong seasonal component related to activities on Georges Bank; the vast majority of the effort is expanded during spring and summer.

Except for 1985, the mean weight of scallop meats shucked has been considerably smaller than in neighbouring Middle Grounds, (Table 5). Scallops between 7 and 10 years of age made up about 50 % of the catch. Beginning in 1988 the average meat weight in the catch has risen gradually from 11.6 to 16.6 g in 1993, suggesting a minimum input of young age classes recruiting to the fishery.

The 1993 eastern Shelf stock survey of Western Bank and the Sable Island area had 80

stations randomly stratified by catch (Table 6). Since the start of annual stock surveys, the 1988 survey had observed the second greatest abundance at age (Table 9) with sizable quantities of prerecruits and quite a few recruits as well (Table 10), especially young recruits (ages 5-6). These age groups have passed through. The stratified average for each of the last 4 surveys (since 1990) (Table 9) indicates low abundance for every single age group. The 1993 survey did not reveal any improvement with respect to pre-recruits.

Browns Bank / Tusket Area

Prior to 1989, scallop aggregations, when commercially important, had been found along the southern edge of Browns Bank (NAFO sub-subarea 4Xp) around the 100 m isobath and on the northern side of the Bank (Tusket, NAFO sub-subarea 4Xo) but in much deeper waters. With the 1986 Inshore / Offshore Agreement these scallop beds may be exploited by the deep-sea fleet only. Table 11 has fishery characteristics data for the deep-sea fleet only. Despite discrepancies between statistical landings and logged catches, the scallop production from the Browns Bank area has decreased erratically until a small resurgence of landings in 1988 associated with very high catch-rates at 1.8 kg/crhm.

In 1989 industry requested that the fishery in NAFO SA 4X covering Browns Bank, Tusket and German / Lurcher scallop grounds be managed under an Enterprise Allocation program with a meat count distinct for these grounds. A meat count of 55 per 500 g was agreed upon between industry and fishery managers. Up to 1993, although the TAC covered Browns Bank, Tusket and German / Lurcher, the vast majority of catches were from Browns Bank and the Tusket area. In 1993 Browns Bank - Tusket got split from German / Lurcher and each fishing area got its own TAC. The meat count remained the same. Prior to 1993 the fishery opened in June and lasted until mid-July at best. A higher TAC in 1993 allowed for dispersion of the effort from June to October.

Since the Browns Bank fishery has been managed by quotas, catches have reached the quota figures or exceeded slightly. The area under exploitation is on the northern side of Browns Bank and expanded itself gradually to now cover approximately 500 km². Despite its small size it has provided good to excellent catch-rates although they fluctuate from 0.5 to 0.8 kg / crhm (NAFO SA 4Xp); Tusket, of smaller importance, (NAFO SA 4Xo) has even better catch-rates. Around 575 t of the 600 t TAC have been caught for 1993. It would appear that vessels from the Bay of Fundy fleet have ventured on Browns Bank during the latter part of the year. It is not possible to quantify what has been removed but one may reasonably assume that the quota was fished in its entirety if not exceeded. The best CPUE's since a quota was put in place were encountered in 1993 (Table 11), fishing the same grounds than in previous years.

The meat weight distribution in the catch (Table 12) varied greatly in earlier years but the percentage examined is too small to draw any conclusion. Browns Bank catches were not sampled after 1984 until the beginning of the fishery in 1989. According to catch sampling the average meat weight of the 1989 fishery was quite small, under 9 g; in fact, it is one of the main reasons why the fishery shut down before reaching its quota. Meat weights landed have been rising steadily after that. The past two years, 1992 and 1993, have seen a net improvement in the average weight corresponding to counts of 34 and 32 respectively. From a yield point of view, the counts observed are far superior to the 55 meats per 500 g count now in effect. The improvement in meat count is not due to the pursuit of a single large year-class that would have sustained the fishery over the last 5 years, but to the exploitation of multiple relatively good year-classes and careful blending. The percentage of the catch examined has improved markedly since 1991; the data could eventually be used in analytical assessments.

Two main scallop beds (Area 1 and Area 2) (Fig. 3) were identified from the mapping of catch-rates distribution in 1993. Overall, the area with high CPUE's (1.0 kg / crhm) was substantial relatively speaking. Once boundaries had been established for each bed, the fishery data was segregated on the basis of its area of origin and a time element. Table 13 lists catch removals, CPUE's, and meat counts for each area and each month of fishing activity. The number of observations corresponds to the number of fishing days for the fleet for any particular month. Figures 4 and 5 illustrate for Area 1 and Area 2 respectively, the level of catches and CPUE's

during the course of the fishing season (upper graph); the bottom graph plots monthly CPUE's and cumulative catch. Area 1 had one-third more catches than Area 2 (288 vs 196 t); CPUE's were also better and the count slightly lower. Area 1 is relatively shallower than Area 2, hence better growth-rate. Also, Area 1 recovered more rapidly from the gradual, seasonal decline in CPUE's caused by spawning compared to Area 2. Actually, September rates are similar to June rates in Area 1; the meat count rose through the season and did not revert. In Area 2 September CPUE's were only 66 % of June rates; the count had also risen from 33 to 39 meats per 500 g. The observations for October are questionable because of the limited number of fishing days involved. Even though the count was rising as the fishing season progressed, a sign of smaller meats being blended in the catch, the catch-rates could bounce back to original levels after an in-season decline. It does not appear that the cumulative catches have had a negative effect on catch-rates.

Previous surveys had found high concentrations of age 2 juveniles in a well delimited area of southeastern Browns Bank. However, these year classes did not contribute to a fishery renewal. Very heavy mortality rates appear to have been experienced by possibly 3 successive year classes of scallops on the southern edge of Browns Bank (Robert *et al.* MS 1986). Both the 1986 and 1987 surveys established the paucity of prerecruits and recruits (Table 14). Survey work was interrupted after that.

Stock surveys were resumed after the experimental fishery started. The 1990, 1991, and 1992 survey results indicated that recruited densities were good (Table 15) and, more importantly, prerecruits and juveniles were present in sizable quantities (Table 14). But, the elevated densities of prerecruits were found in highly localised areas. This may partially explain the possible drop in prerecruits abundance in the 1993 survey; the assigned sampling missing the highly localised patches.

Since the growth curve used to establish abundance results on an age basis has not been derived for this scallop bed specifically but from a more southern location on Browns, survey results are also presented according to 5-mm shell height intervals (bottom of table 15). Shell height classes may lead to a more precise relative biomass estimate, the class interval being smaller than age classes. Recruited densities according to shell height intervals (bottom table 15) remained high from 1992 to 1993.

Using the meat weight - shell height allometric relationship developed for this scallop bed, the biomass per standard tow for scallops over 100 mm is given in table 15. All scallops above 100 mm (11.7 g meat) readily meets the 55 meat count without blending. On a tow basis, the 1993 biomass was slightly less than the 1992 biomass. The figures are not corrected for dredge efficiency on those substrates.

German Bank / Lurcher Shoals

NAFO sub-subarea 4Xq includes German Bank and the lower half of the Lurcher Shoals (up to latitude 44° N); the upper half of Lurcher Shoals is part of sub-subarea 4Xr. Statistical landings and logged catches diverge for these respective areas illustrating the misrepresentation resulting from the statistical area boundaries as presently set. Biological differences exist between German Bank and Lurcher Shoals; growth rate being slower on German Bank relative to Lurcher Shoals and the outer reaches of the Bay of Fundy (Robert *et al.* MS 1986). Prior to the Inshore / Offshore Agreement of 1986, the offshore fleet could fish throughout the area (NAFO sub-subarea 4Xq); after 1986 their fishing activities are restricted to below latitude 43° 40' N. Table 16 on German Bank fishery characteristics reflects this situation.

During the early 1980's, catches were important but steadily declined until 1985 (Table 16). Catch-rates were also following the same trends. After 7 years of very little activity the fishery resumed in 1993. However, two points should be considered. As part of the 1989 experimental fishery on the western Scotian Shelf, approximately 5 t were caught on German Bank, at a moderate CPUE and a one day incursion in 1992 produced excellent catch-rates. Also there are reports that in 1992, vessels from the Bay of Fundy fleet made an undetermined number of trips south of the Line at 43° 40'; but it was not possible to quantify amounts removed. The 1993 TAC of

200 t was caught in its entirety over a brief 6 weeks period starting in June; CPUE's were high at 0.756 kg / crhm. Incursions of vessels from the Bay of Fundy fleet continued to take place during 1993. Reports from the fishermen involved would have them fishing well into the fall. From estimates of mean landing per trip, number of vessels involved and frequency of such trips, an additional 700 t could easily have been harvested from German Bank.

Sampling of the catch has been scanty or did not take place (Table 17). The large meat weight (mean, 48 g) sampled in 1989 suggests that the effort was expanded on remnants of the population that had sustained the German Bank fishery prior to 1985. In 1993 the average meat weight in the catch corresponds to a count under 30 per 500 g. But not all size classes were represented. There were patches of relatively small scallops with meats 10 g or less, a few beds with weights in the 15 - 20 g range and isolated pockets of very large meats reflected by the maximum weight sampled of nearly 70 g.

The abundance of large, old scallops was declining according to the last survey results available. Very low levels of fishing activity took place between 1985-89. The annual stock survey did not extend to the German Bank / Lurcher Shoals area after 1985.

DISCUSSION AND CONCLUSION

Given the state of the stocks on the eastern Scotian Shelf and the relatively poor fishery performance provided, the eastern Scotian Shelf grounds appear to require alternative management strategies to reduce exploitation to possibly improve stock levels. Other avenues besides the present competitive fishery regime should be explored.

The western Scotian Shelf (NAFO 4X) operates under a non-competitive management regime. 1993 saw separate quotas for Browns and German Banks. The following table provides TAC figures and catch landed since the exploitation of that area began under the E.A. plan.

Year	TAC (t)		Catch (t, 4X total)*
1989	400	set by industry	363
1990	200	biological advice	212
1991	220	" "	210
1992	450	" "	454
1993	600	" "	575

* 1993 Browns Bank (NAFO, 4Xo and p) only.

Despite the TAC increase from 450 to 600 t for Browns Bank in 1993, these harvest levels did not cause the overall stock biomass to get depleted enough to produce lower catch-rates. The abundance of prerecruits could so far renew the stock supply; exploitation taking place on the same scallop beds. On an annual basis, 1993 CPUE's have improved over 1992. However, monitoring fishery performance on a scallop bed basis as tried with the 1993 data allowed a much better insight of fishery characteristics during the course of the fishing season. Although a seasonal decline was observed in catch-rates, they did bounce back up. This was likely due mainly to the inclusion of new recruits in the catch near the end of the fishing season as indicated by the steady rise of monthly meat counts.

The catch removals from German Bank, estimated at 900 t total, far exceeded the TAC levels that had been set and create uncertainty as to the present state of the stocks.

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Table 1.- Updated biological data on growth-rate and meat yield (year round values) for scallop fishing grounds on the Scotian Shelf. N = number of scallops examined.

	Growth	Yield
Banquereau Bank	N = 60 $H_{\infty} = 128.105$ mm $t_0 = 1.5233$ $k = 0.2579$	N = 90 intercept = -11.003 slope = 2.913
Middle Grounds	N = 414 $H_{\infty} = 156.210$ mm $t_0 = 1.3650$ $k = 0.1980$	N = 289 intercept = -10.305 slope = 2.801
Sable, Western Bank	N = 3,716 $H_{\infty} = 136.628$ mm $t_0 = 1.3375$ $k = 0.2269$	N = 3,734 intercept = -11.381 slope = 2.999
Browns Bank	N = 459 $H_{\infty} = 109.910$ mm $t_0 = 1.4402$ $k = 0.2873$	N = 600 intercept = -10.968 slope = 2.914

Table 2.- Number of vessels from the deep-sea fleet fishing scallop grounds on the Scotian Shelf as per log information. The Western Shelf includes German Bank / Lurcher Shoals, Browns Bank, and the Tusket area. The Eastern Shelf includes Middle Grounds, Western Bank, the Sable Island area, and Banquereau Bank. The last column indicates the number of vessels that used both areas of the Shelf.

Year	Western Shelf	Eastern Shelf	Scotian Shelf
1986	4	55	3
1987	0	33	0
1988	3	15	1
1989	29	35	16
1990	24	34	13
1991	22	30	12
1992	31	30	20
1993	34	27	23

Table 3.- Fishery characteristics for the Banquereau Bank area (NAFO 4V) for the deep-sea fleet. Landings and catches are in t of scallop meats. Landings are from Statistics Division, Fisheries and Oceans, Halifax. Effort pertains to Class 1 catch only.

Year	Landings	Logged catches	Class 1 catch	Effort (crhm)	CPUE (kg/crhm)
1980	3.30	7.17	7.17	20,171	0.355
1981	0.00	0.00	--	--	--
1982	0.69	0.42	0.42	1,092	0.387
1983	5.37	3.26	3.26	7,343	0.444
1984	3.18	0.63	0.63	939	0.672
1985	0.24	N/A	N/A	N/A	N/A
1986	15.64	11.15	10.98	45,849	0.239
1987	0.65	0.51	0.51	4,617	0.110
1988	0.00	0.00	0.00	0,000	--
1989	0.00	0.00	0.00	0,000	--
1990	0.83	0.00	0.00	0,000	--
1991	0.63	0.81	0.81	3,388	0.240
1992	2.82	2.50	2.50	8,231	0.303
1993	5.79	6.84	6.84	25,865	0.264

Table 4.- Fishery characteristics for the Middle Grounds area (NAFO 4We) for the deep-sea fleet. Landings and catches are in t of scallop meats. Landings are from Statistics Division, Fisheries and Oceans, Halifax. Effort pertains to Class 1 catch only.

Year	Landings	Logged catches	Class 1 catch	Effort (crhm)	CPUE (kg/crhm)
1980	3.65	1.42	1.42	5,434	0.262
1981	-	-	-	-	-
1982	72.39	62.09	61.12	122,106	0.501
1983	105.16	104.92	100.59	309,055	0.325
1984	11.90	9.94	8.34	47,585	0.175
1985	26.89	21.59	21.59	99,345	0.217
1986	51.27	51.28	50.46	345,552	0.146
1987	6.70	7.03	6.64	44,274	0.150
1988	0.28	0.29	0.29	1,707	0.169
1989	20.84	21.70	21.70	66,551	0.326
1990	19.04	33.63	33.63	109,777	0.306
1991	31.54	35.18	35.18	96,411	0.365
1992	38.68	43.12	43.12	151,744	0.284
1993	39.11	53.72	16.88*	63,108	0.267

Fishery characteristics for Sable Island and Western Bank (NAFO 4Wf-j)

1980	60.99	50.48	50.48	219,987	0.229
1981	0.56	0.00	0.00	0	-
1982	64.10	61.40	61.40	243,779	0.252
1983	185.15	166.47	164.45	886,072	0.186
1984	71.30	64.65	63.58	370,231	0.172
1985	64.93	76.00	76.00	294,217	0.258
1986	618.35	585.26	551.88	3,070,138	0.180
1987	415.80	412.01	394.23	2,339,915	0.168
1988	100.43	100.42	93.99	414,920	0.227
1989	516.39	515.36	489.54	1,830,668	0.267
1990	414.25	403.94	387.07	1,615,586	0.240
1991	356.40	352.57	337.34	1,188,495	0.284
1992	482.57	477.88	460.75	1,900,188	0.242
1993	204.46	186.11	93.57*	487,736	0.192

* excludes roe fishery.

Table 5.- Nature of the catch from NAFO SA 4W determined by analyses of scallop meat weights.

%	catch examined	meat weight (g)				n meats
	catch landed	mean	min	max	s.e.	
Middle Grounds						
1983	0.0240	20.00	3.04	69.99	0.13	1,259
1984	0.0392	14.84	4.23	46.97	0.14	314
1985	0.0175	22.88	6.31	66.40	0.22	217
1986	0.0134	22.73	4.33	61.51	0.23	302
1987	0.0436	21.48	2.34	68.23	0.30	137
1988	-	-	-	-	-	-
1989	0.0441	14.46	4.22	61.45	0.11	636
1990	0.0417	16.45	5.74	59.69	0.16	483
1991	-	-	-	-	-	-
1992	-	-	-	-	-	-
1993	0.0125	13.45	5.38	68.45	0.13	499
Sable Island/Western Bank						
1980	0.0133	9.46	3.87	22.11	0.04	860
1981	-	-	-	-	-	-
1982	0.0015	9.15	4.65	15.38	0.11	102
1983	0.0339	13.49	2.25	72.43	0.04	4,658
1984	0.0161	11.10	2.65	42.48	0.07	1,034
1985	0.0025	27.41	11.27	54.30	0.52	62
1986	0.0271	15.03	2.33	79.13	0.03	11,397
1987	0.0319	14.35	2.22	98.14	0.04	9,226
1988	0.0045	11.57	4.07	34.60	0.09	394
1989	0.0215	13.14	3.16	72.91	0.02	8,440
1990	0.0099	13.97	2.52	71.89	0.05	2,994
1991	0.0050	13.08	4.25	31.31	0.04	1,365
1992	0.0114	15.37	3.46	59.51	0.04	3,526
1993	0.0178	16.58	2.55	68.88	0.07	2,022

Table 6.- Number of survey stations in NAFO SA 4V and 4W by year and by stratum type.

Banquereau Bank	1987	1988	1989	1990	1991	1992	
exploratory	5	5	6	0	0	0	
total	5	5	6	0	0	0	
Middle Grounds	1986	1987	1988	1989	1990	1991	1992
explo/low catch	4	6	6	0	0	0	8
medium catch	-	-	-	-	-	-	-
high catch	6	6	-	-	-	-	-
total	10	12	6	0	0	0	8
Sable/Western Bank	1987	1988	1989	1990	1991*	1992	1993
low catch	5	4	11	10	4	20	21
medium catch	27	14	33	30	22	24	29
high catch	58	72	62	50	50	26	18
exploratory	-	-	-	-	-	12	12
total	90	90	106	90	76	82	80

* The original allocation by stratum was not followed in 1991. Shipcrew overtime restrictions did not allow for the scheduled coverage of the sampling area.

Table 7.- Average number of scallops at age caught in a lined 2.44m New Bedford offshore dredge by catch stratum, Middle Grounds.

	Age (years)									Mean	s.d.
	2	3	4	5	6	7	8	9	10+		
1983 stock survey											
low	0	0	0	1	0	0	0	0	0	2	2
medium	0	0	2	13	8	1	0	0	2	26	15
high	0	0	3	31	9	0	0	0	1	55	67
1984 stock survey											
low	0	0	0	2	1	2	1	0	0	8	10
high	0	0	0	2	6	4	2	1	2	17	16
1985 stock survey											
low	0	0	3	6	2	4	1	0	0	20	23
high	0	0	0	0	0	3	3	0	1	10	13
1986 stock survey											
low	0	0	0	0	0	0	1	1	3	7	7
high	0	0	1	0	3	6	4	2	2	17	10
1987 stock survey											
low	0	2	0	1	1	0	0	1	2	6	8
high	0	0	0	0	0	1	1	0	3	6	4
1988 stock survey exploratory	5	10	16	4	2	1	1	1	2	51	56
1992 stock survey exploratory	1	6	3	7	3	1	1	0	0	22	27

Table 8.- Summary of average number of scallops at age caught for prerecruits, shell height under 75mm or age less than 5 years, and recruits, shell height over 75mm by catch stratum, for the Middle Grounds area.

	Age (years)		
	2-4	5-10	11+
Middle Grounds			
1983 stock survey			
low	0	1	0
medium	2	23	1
high	3	40	1
1984 stock survey			
low	0	6	0
high	0	16	1
1985 stock survey			
low	3	13	0
high	0	6	1
1986 stock survey			
low	0	4	1
high	1	16	1
1987 stock survey			
low	2	4	1
high	0	3	2
1988 stock survey			
exploratory	31	10	1
1992 stock survey			
exploratory	10	12	0

Table 9.- Average number of scallops at age caught in a lined 2.44 m New Bedford offshore dredge by catch stratum in the Sable Island - Western Bank area.

	Age (years)									Mean	s.d.	
	2	3	4	5	6	7	8	9	10+			
1988 stock survey												
low	1	2	1	0	0	0	0	1	3	7	4	
medium	3	6	8	11	10	4	1	1	4	48	70	
high	25	41	48	50	29	10	3	2	3	210	222	
1989 stock survey												
low	3	8	5	7	3	2	0	0	3	33	57	
medium	0	2	4	7	6	3	1	1	4	28	38	
high	8	34	50	42	24	10	4	1	2	181	229	
1990 stock survey												
low	4	1	1	2	3	2	1	1	2	21	34	
medium	2	2	6	8	8	4	2	1	3	38	47	
high	22	9	26	31	23	9	3	1	2	130	107	
1991 stock survey												
low	1	9	7	11	8	10	6	4	5	60	60	
medium	1	9	5	8	9	6	2	1	3	45	47	
high	2	16	7	9	11	7	3	1	2	57	83	
1992 stock survey												
low	13	3	8	8	6	4	2	1	3	49	77	
medium	4	8	22	12	12	7	3	2	3	74	69	
high	14	8	20	17	15	8	3	1	1	88	95	
1993 stock survey												
low	1	7	6	7	6	4	3	2	4	39	37	
medium	2	14	15	24	10	6	3	2	4	79	77	
high	4	22	25	35	20	11	4	1	1	123	62	
Stratified average for each survey:												
1988	21	34	40	42	25	9	3	2	3			
1989	5	21	31	27	16	7	3	1	3			
1990	13	6	17	20	16	7	2	1	2			
1991	2	14	6	9	10	7	3	1	2			
1992	10	7	17	13	11	7	3	1	2			
1993	2	12	13	19	10	6	3	2	3			

Table 10.- Summary of average number of scallops at age per tow for prerecruits (shell height under 75 mm or age less than 5 years) and recruits (shell height over 75 mm) by catch stratum in the Sable Island - Western Bank area.

	Age (years)		
	2-4	5-10	11+
1987 stock survey			
low	3	6	5
medium	12	20	5
high	70	61	4
1988 stock survey			
low	4	2	2
medium	17	28	3
high	114	95	2
1989 stock survey			
low	16	12	3
medium	6	19	3
high	92	82	1
1990 stock survey			
low	6	9	2
medium	11	24	2
high	56	67	1
1991 stock survey			
low	17	41	3
medium	15	27	2
high	25	32	1
1992 stock survey			
explo/very low	4	10	4
low	24	22	2
medium	34	37	2
high	42	43	1
1993 stock survey			
explo/very low	8	16	3
low	14	23	3
medium	31	46	3
high	51	72	0

Table 11.- Fishery characteristics for the Browns Bank - Tusket area (NAFO 4Xp and 4Xo) for the deep-sea fleet. Landings and catches are in t of scallop meats. Landings are from Statistics Division, Fisheries and Oceans, Halifax. Effort pertains to Class 1 catch only.

Year	Landings	Logged catches	Class 1 catch	Effort (crhm)	CPUE (kg/crhm)
4Xo					
1979	0.00	13.70	13.70	21,964	0.624
1980	13.17	40.79	33.41	60,979	0.548
1981	0.36	1.40	1.40	2,219	0.632
1982	47.55	70.87	65.76	86,204	0.763
1983	42.70	53.11	44.96	78,613	0.572
1984	10.57	13.24	13.24	45,619	0.290
1985	0.00	0.84	0.84	2,155	0.389
1986	0.00	0.00	0.00	0	-
1987	0.00	0.00	0.00	0	-
1988	4.22	0.00	0.00	0	-
1989	16.14	42.31	35.04	44,918	0.780
1990	8.95	34.73	34.73	61,132	0.568
1991	4.76	24.31	20.13	35,358	0.569
1992	0.96	12.50	12.50	12,058	1.037
1993	0.13	18.50	17.50	15,212	1.150
4Xp					
1979	73.05	77.90	76.62	145,118	0.528
1980	258.23	205.91	199.25	479,388	0.416
1981	24.98	12.86	12.65	19,578	0.646
1982	114.07	83.40	82.84	217,580	0.381
1983	63.32	34.83	33.46	135,526	0.247
1984	16.60	4.95	4.95	26,565	0.186
1985	6.93	15.54	15.54	36,413	0.427
1986	4.64	4.00	4.00	6,948	0.576
1987	0.00	0.00	0.00	0	-
1988	0.00	5.16	5.16	2,853	1.808
1989	321.20	277.76	189.98	287,667	0.660
1990	172.44	170.95	146.01	275,101	0.531
1991	197.29	177.01	145.70	262,186	0.556
1992	452.84	441.11	393.93	524,935	0.750
1993	575.30	556.10	521.16	634,585	0.821

Table 12.- Nature of the catch from Browns Bank / Tusket area determined by analyses of scallop meat weights.

	%	catch examined	meat weight (g)			
		catch landed	mean	min	max	s.e.
1979		0.0022	16.29	4.01	58.66	0.18
1980		0.0195	10.54	1.37	87.46	0.04
1981		0.0080	35.75	13.71	55.37	0.35
1982		0.0020	16.39	2.90	47.13	0.18
1983		0.0000	---	---	---	---
1984		0.0062	21.98	6.46	68.63	0.51
1985		0.0000	---	---	---	---
1986		0.0000	---	---	---	---
1987		0.0000	---	---	---	---
1988		0.0000	---	---	---	---
1989		0.0388	8.93	3.70	49.90	0.01
1990		0.0022	10.43	4.13	42.79	0.07
1991		0.0115	12.65	4.69	49.46	0.04
1992		0.0187	14.62	5.71	48.36	0.02
1993		0.0131	15.59	5.23	62.90	0.02

Table 13.- Monthly characteristics of the fishery on 2 scallop beds on Browns Bank.

Browns Bank Area 1

Month	No.Observations	Catch (tons)	CPUE	Count
June	49	88	0.91	30.0
July	34	63	0.89	32.3
August	33	54	0.64	33.5
September	50	77	0.91	35.2
October	2	6	0.92	34.8

Browns Bank Area 2

Month	No.Observations	Catch (tons)	CPUE	Count
June	52	87	0.89	32.7
July	29	48	0.76	33.2
August	20	33	0.74	39.0
September	18	24	0.59	38.7
October	3	4	1.19	40.0

Table 14.- Summary of average number of scallops at age per tow for prerecruits (shell height under 75 mm or age less than 5 years) and recruits (shell height over 75 mm) by catch stratum.

	Age (years)		
	1-4	5-10	11+
Browns Bank / Tusket 1983			
low	416	6	1
high	308	9	7
Browns Bank / Tusket 1984			
low	0	0	0
medium	156	11	11
high	61	34	1
Browns Bank / Tusket 1985			
exploratory	247	6	11
low	0	0	0
high	1	0	2
Browns Bank / Tusket 1986			
exploratory	1	8	4
low	0	0	1
high	1	0	1
Browns Bank / Tusket 1987			
exploratory	12	2	2
Browns Bank / Tusket 1990			
exploratory	362	165	20
Browns Bank / Tusket 1991			
exploratory	563	152	27
Browns Bank / Tusket 1992			
exploratory	1227	356	60
Browns Bank / Tusket 1993			
exploratory	121	142	48

Table 15.- Average number of scallops per tow caught in a lined 2.44 m New Bedford offshore dredge in the Browns Bank / Tusket area on an age basis and estimated minimum dredgeable biomass per tow for 5-mm shell height intervals over 100 mm corresponding to a meat count of 55 or less.

	Age (years)									Mean	s.d.
	2	3	4	5	6	7	8	9	10+		
1990 stock survey exploratory	174	122	65	60	35	26	20	15	29	547	713
1991 stock survey exploratory	250	186	127	55	29	25	21	15	34	742	1100
1992 stock survey exploratory	600	385	242	115	107	63	35	23	73	1702	2409
1993 stock survey exploratory	4	57	60	21	29	27	27	23	63	312	442
	Shell height intervals							total (g)			
	100-105	105-110	110-115	115-120	120-125	125-130	130-135				
1991 survey		190	147	84	57	38	33	4	553		
1992 survey		336	314	262	160	65	20	5	1162		
1993 survey		390	265	152	99	57	22	8	993		

Table 16.- Fishery characteristics for the German Bank / Lurcher Shoals area (NAFO 4Xq) for the offshore fleet (vessels over 19.8m). Landings and catches are in t of scallop meats. Landings are from Statistics Division, Fisheries and Oceans, Halifax. Effort pertains to Class 1 catch only.

Year	Landings	Logged catches	Class 1 catch	Effort (crhm)	CPUE (kg/crhm)
1979	102.32	147.10	145.20	157,729	0.921
1980	1269.71	1132.69	1021.86	1,614,441	0.633
1981	379.69	207.63	188.78	318,221	0.593
1982	659.74	535.84	403.51	954,628	0.423
1983	587.76	465.88	420.45	1,092,569	0.385
1984	207.13	175.83	156.45	581,969	0.269
1985	33.76	16.60	15.91	46,295	0.344
1986	1.59	0.00	0.00	0	---
1987	0.00	0.00	0.00	0	---
1988	0.00	0.00	0.00	0	---
1989	5.54	4.54	4.01	9,112	0.440
1990	0.00	0.00	0.00	0	---
1991	0.00	0.00	0.00	0	---
1992	0.25	0.25	0.25	254	0.998
1993	200.00*	192.66	161.34	213,531	0.756

* estimated additional removals.

Table 17.- Nature of the catch from German Bank determined by analyses of scallop meat weights from the offshore fleet for selected years when a fishery took place.

	catch examined	meat weight (g)			
	catch landed	mean	min	max	s.e.
1983	0.0010	11.99	3.35	44.13	0.11
1984	0.0008	22.69	3.88	53.52	0.42
1989	0.1012	47.93	27.41	76.19	0.32
1993	0.0142	17.41	5.20	67.10	0.06

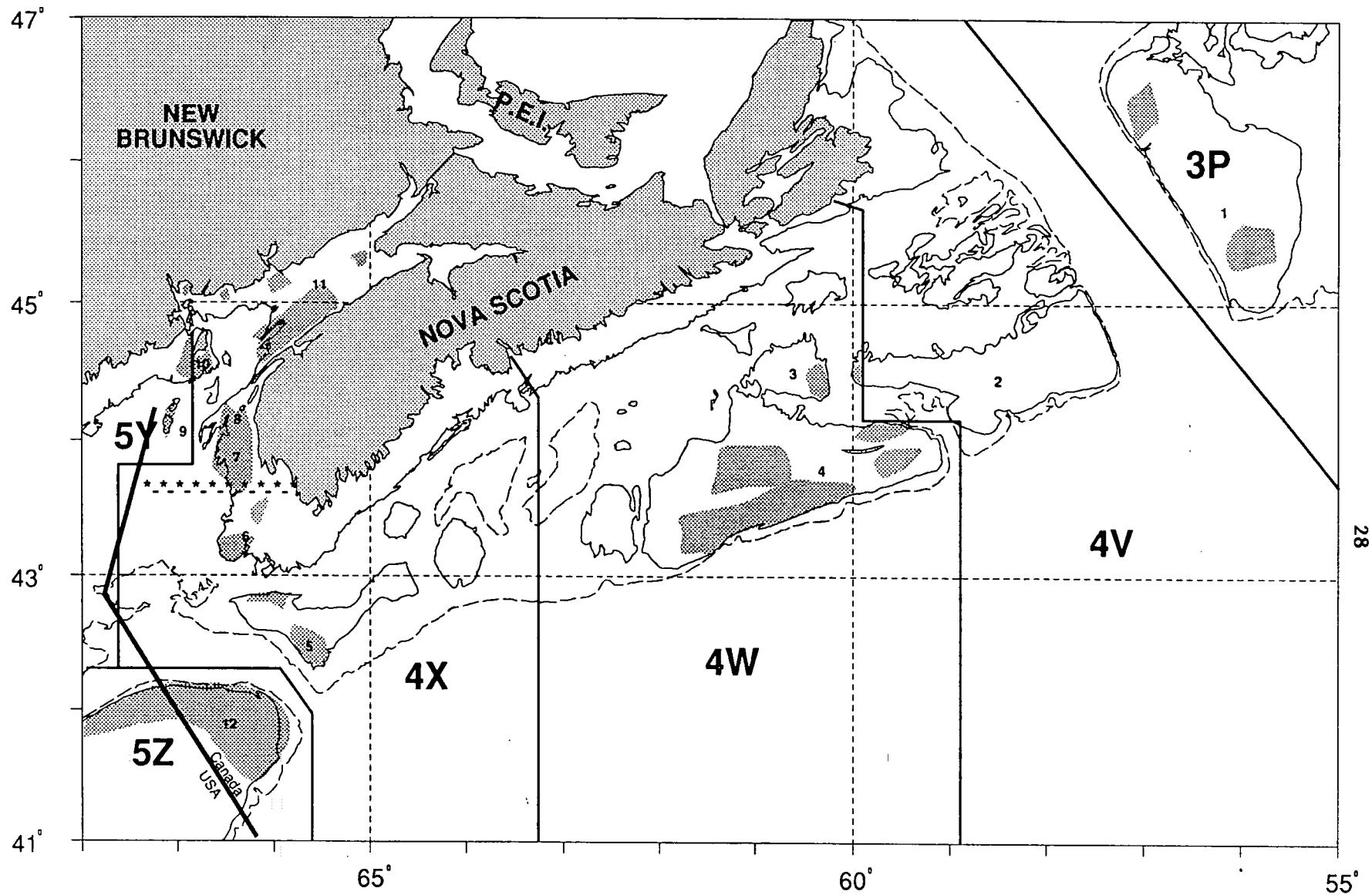


Figure 1.- Scallop fishing areas on the Scotian Shelf and St. Pierre Bank. The 100 and 200-m isobaths are represented. Areas in numerical order are: (1) St. Pierre Bank; (2) Banquereau Bank; (3) Middle Grounds; (4) Sable Island area; (5) Browns Bank; (6) German Bank; (7) Lurcher Shoals; (8) Outer reaches of the Bay of Fundy; (9) Southwest Bank; (10) Grand Manan area and (11) the Bay of Fundy area. Georges Bank (12) is also shown. A line of asterisks shows the $43^{\circ} 40'$ line below (7) Lurcher Shoals.

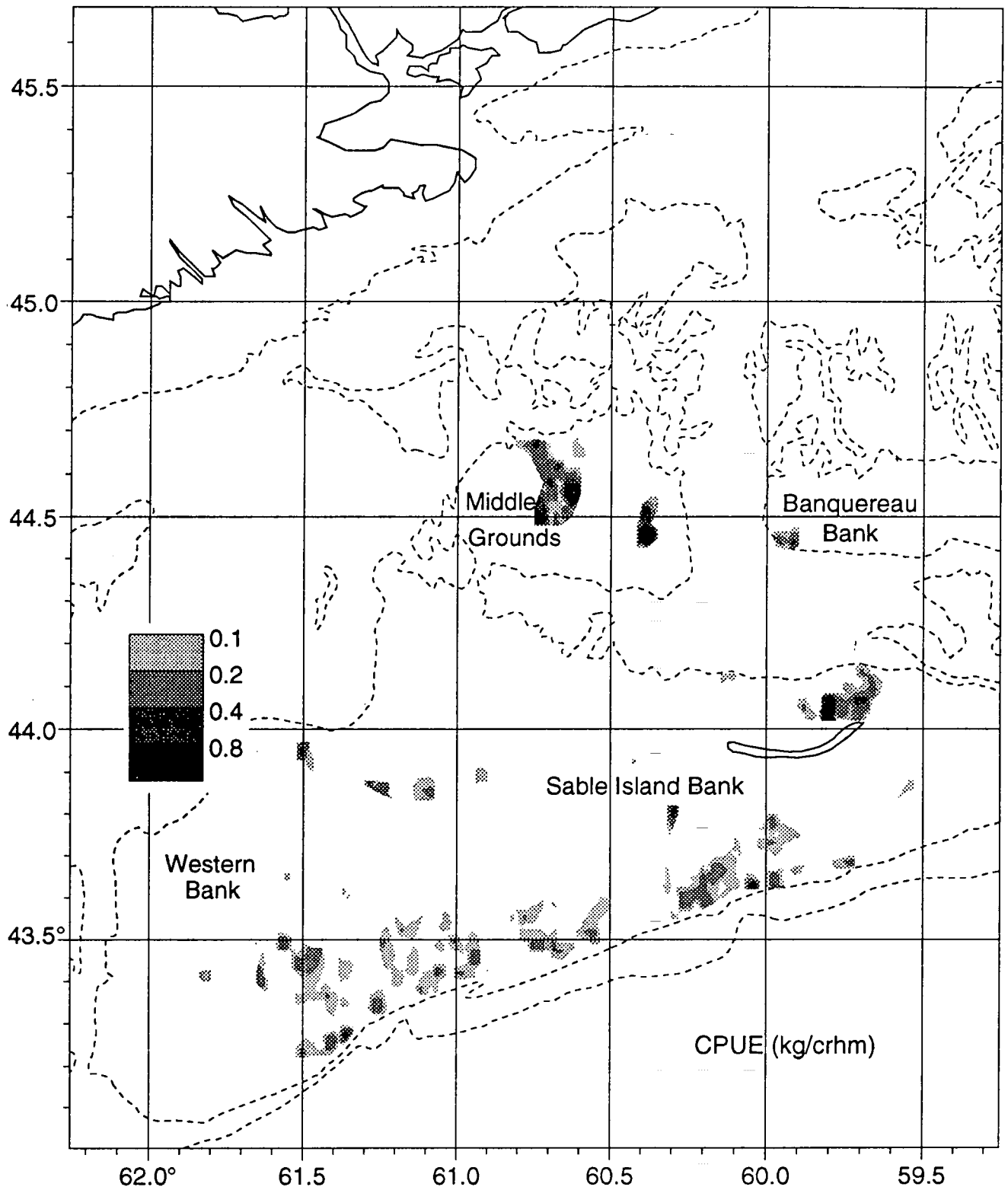


Figure 2.- Distribution of commercial CPUE by the deep-sea fleet on the eastern Scotian Shelf in 1993. The darkest shade represents over 0.8 kg/crhm.

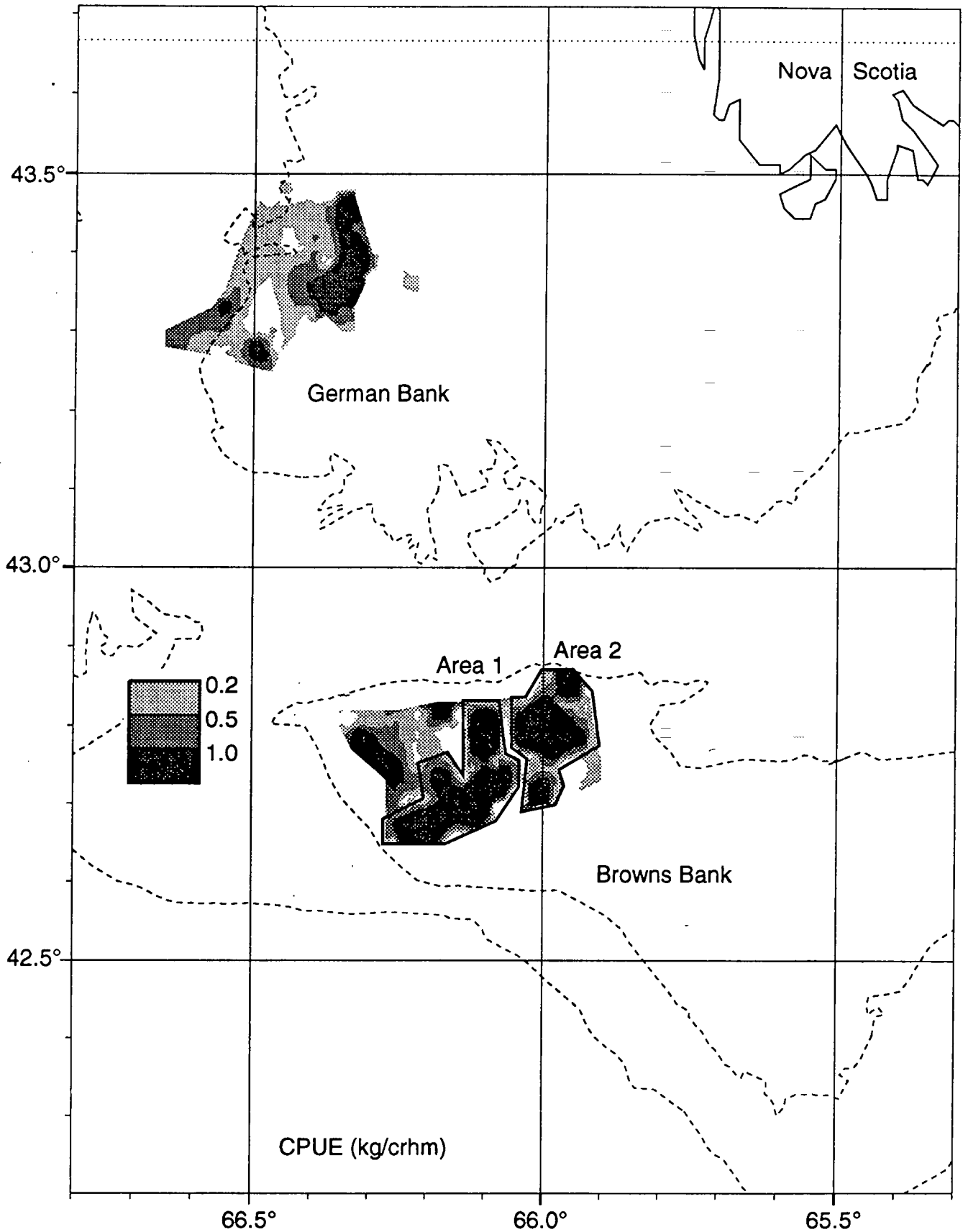


Figure 3.- Distribution of commercial CPUE by the deep-sea fleet on the western Scotian Shelf in 1992. The darkest shade represents over 1 kg/crhm. Area 1 and Area 2 represent the 2 main scallop beds on Browns Bank. The dotted line on the Lurcher-Shoals indicates the Inshore / Offshore Agreement line at latitude 43 ° 40'.

Browns Bank Area 1

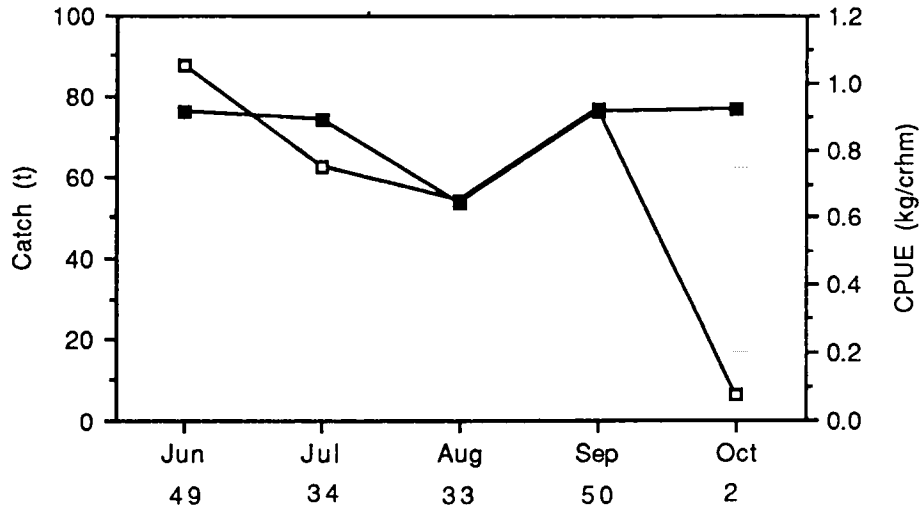


Figure 4a. Monthly CPUE (closed square) and catch in tons of meats (open square) for Browns Bank Area 1. Numbers of observations are indicated below each month.

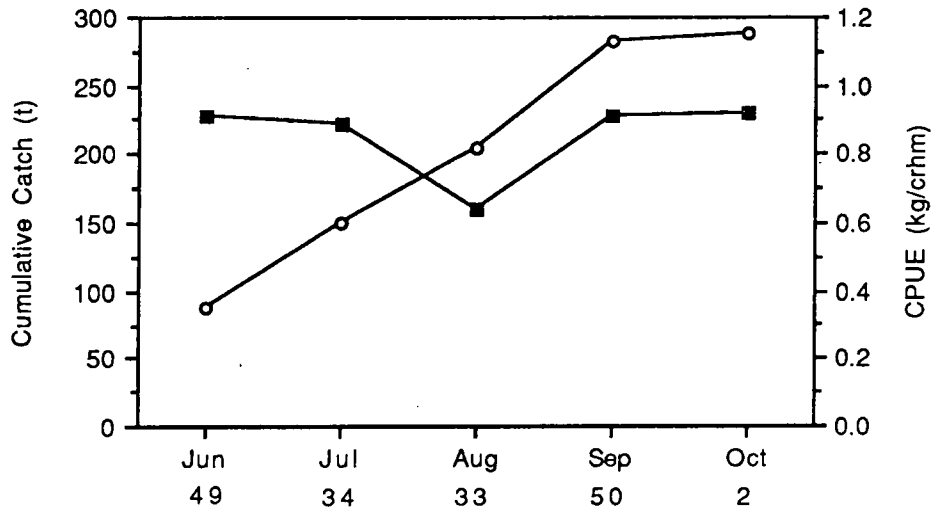


Figure 4b. Monthly CPUE (closed square) and cumulative catch (open square) in tons of meat for Browns Bank Area 1. Numbers of observations are indicated below each month.

Browns Bank Area 2

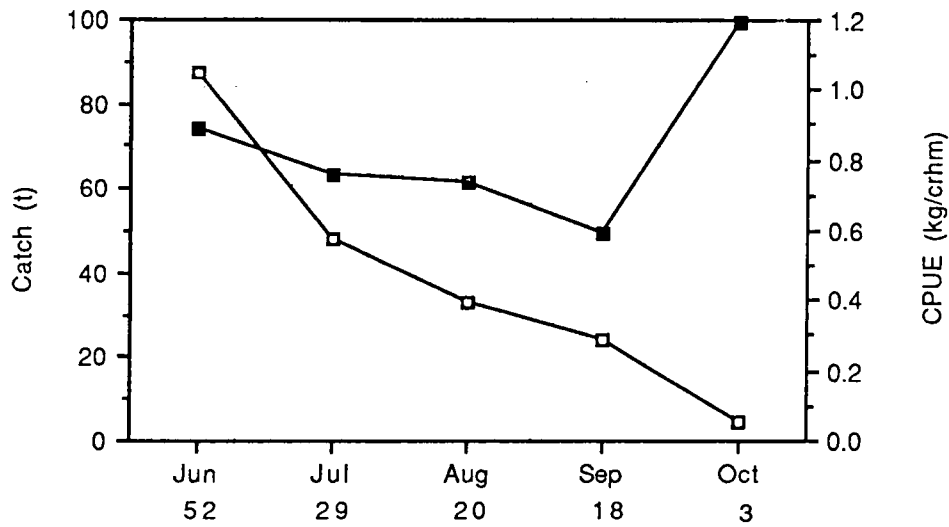


Figure 5a. Monthly CPUE (closed square) and catch in tons of meats (open square) for Browns Bank Area 2. Numbers of observations are indicated below each month.

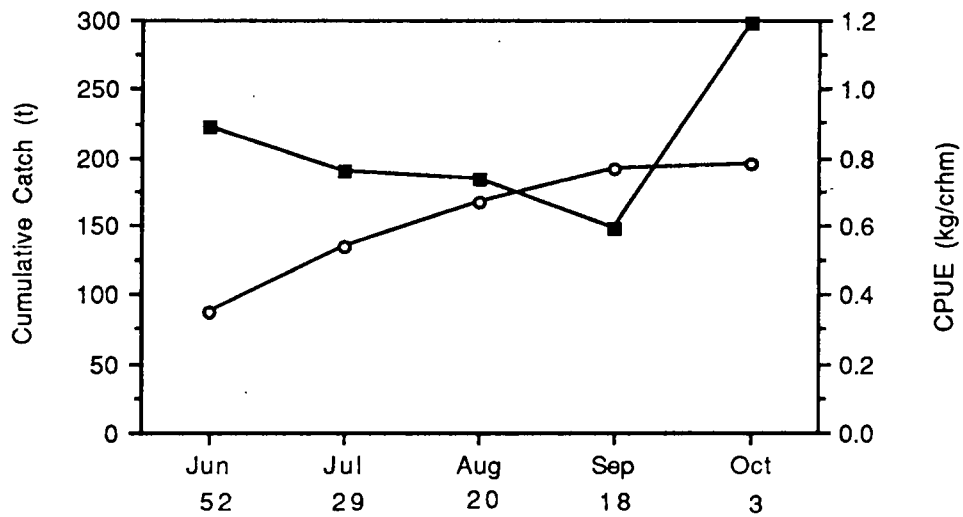


Figure 5b. Monthly CPUE (closed square) and cumulative catch (open circle) in tons of meats for Browns Bank Area 2. Numbers of observations are indicated below each month.